USAAEFA PROJECT NO. 75-17-1

FLIGHT EVALUATION
PACER SYSTEMS LOW-RANGE AIRSPEED SYSTEM LORAS 1000

FINAL REPORT

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The Pacer Systems Inc. low-range airspeed system (LORAS 1000) was evaluated on a helicopter by the United States Army Aviation Engineering Flight Activity at Edwards Air Force Base, California, in February and March 1976. Properly calibrated and aligned, the LORAS 1000 accurately displays low airspeeds along the longitudinal and lateral axes. When located above the rotor hub resultant airspeed is also displayed. In forward and rearward flight the system output was linear except for small discontinuities at -10 and +10 knots true airspeed (KTAS). The system output was repeatable for the range tested (31 KTAS rearward to 122 KTAS forward). The density altitude displayed values were accurate for the range tested. No reliability or maintainability problems were encountered.

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INTRODUCTION

BACKGROUND

1. Standard pitot-static airspeed systems are inadequate for low-airspeed (below 40 knots) sensing in helicopters, and are inoperable in crosswind or downwind flight conditions. The United States Army Aviation Engineering Flight Activity (USAAEFA) conducted tests on several low-airspeed omnidirectional systems during USAAEFA Project No. 71-30 (refs 1 through 6, app A). The United States Army Avionics Laboratory, Fort Monmouth, New Jersey, is currently developing a lightweight doppler navigation system (LDNS) which requires inputs from an airspeed sensor that will operate reliably in the low-speed nap-of-the-earth (NOE) flight regime. In May 1975, the United States Army Aviation Systems Command (AVSCOM) directed USAAEFA to evaluate two systems for the Avionics Laboratory (ref 7). A test plan was prepared by USAAEFA to accomplish the evaluation (ref 8). Subsequently, the Avionics Laboratory requested that two additional systems also be tested. One of these additional systems was the Pacer Systems Inc. low-range airspeed system (LORAS).

TEST OBJECTIVES

2. The objective of this evaluation was to define the operating characteristics of the LORAS in an NOE flight environment for possible use with the LDNS. Specific objectives were to define:

a. Airspeed range in which the system is effective.

b. Impact of flight direction on accuracy.

c. Preliminary evaluation of system reliability and maintainability.

DESCRIPTION

3. The LORAS 1000, made by Pacer Systems Inc. of Arlington, Virginia, consists of a sensor unit, air data converter, omnidirectional airspeed/density altitude indicator, and a control panel. The sensor consists of two venturi tubes mounted on opposite ends of a tubular rotor. The venturis are connected to opposite sides of a differential pressure transducer. A motor drives the rotor at a constant speed of 720 rpm in the horizontal plane to assure adequate dynamic pressure in the venturis independent of aircraft motion. The air data converter combines the sensor unit outputs (differential pressure and the corresponding angular position of the venturis) with temperature and static pressure and outputs longitudinal, lateral, and resultant true airspeed. Density altitude is also an optional output of the computer. The system was designed to operate over an airspeed range of 50 knots

true airspeed (KTAS) rearward to 200 KTAS forward and to 50 KTAS in lateral flight. The system was also designed to be insensitive to vertical speed. A detailed description of the system is provided in appendix B.

4. The sensor was mounted on a standpipe which provided a stationary platform above the main rotor hub (photo 1, app B). The aircraft used in this evaluation was an AH-1G, SN 67-15844. A detailed description of the aircraft is contained in the operator's manual (ref 9, app A).

TEST SCOPE

5. The LORAS 1000 was evaluated at Edwards Air Force Base during February and March 1976. A total of 16 productive hours were flown. Flight conditions were within the limitations imposed by the operator's manual and the safety-of-flight release (ref 10, app A). Gross weights were between 7500 and 8300 pounds, with a mid center of gravity (cg).

6. Tests in and out of ground effect were conducted in the low speed (forward, rearward, and sideward) flight regime of the test helicopter at various angles of sideslip. Out-of-ground-effect tests were also conducted in the high-speed forward flight regime at various angles of attack and sideslip.

TEST METHODOLOGY

7. The LORAS was tested to 40 knots at 10 and 50 feet above the ground, using a ground pace vehicle as an airspeed reference. Wind speed and direction were measured and vectorially added to the vehicle ground speed to obtain true airspeed.

8. Airspeeds greater than 40 knots were referenced to the calibrated test boom system. True airspeeds were calculated by correcting calibrated airspeed for air density effects. Angles of attack and sideslip were measured with calibrated boom-mounted flow vanes. A complete list of test instrumentation is contained in appendix C.

9. Lack of a wind tunnel calibration for the LORAS 1000 made distinguishing between system error and position error impossible. However, during the checkout flights, modification of the air data converter to minimize these errors was accomplished by a Pacer representative.

10. Previous testing on a similar LORAS (ref 3, app A) indicated that optimal results would be obtained by mounting the sensor over the main rotor hub. This was the only configuration evaluated during the test.

RESULTS AND DISCUSSION

GENERAL

11. Properly calibrated and aligned, the LORAS 1000 accurately displayed low airspeeds along the longitudinal and lateral axes with the sensor located above the rotor hub. Resultant airspeed was also displayed. In forward and rearward flight the system output was linear, except for small discontinuities at -10 and +10 KTAS. The system output was repeatable for a range from 31 KTAS rearward to 122 KTAS forward. The density altitude displayed values were accurate for the range tested. No reliability or maintainability problems were encountered.

HOVER AND LOW-SPEED FLIGHT

12. Low-speed forward and rearward test results are contained in figure 1, appendix D. At hover, the error was less than 4 KTAS for both 10- and 50-foot skid heights. System output was linear except for small discontinuities at -10 and +10 KTAS. Beyond the discontinuities, output was again linear, with an error of less than 3 KTAS. The 10-foot skid height data show a trend for ground proximity to increase the discontinuities; however, the maximum error was less than 7 KTAS.

13. Sideward flight data are presented in figure 2, appendix D. The data for a 50-foot skid height were repeatable and essentially linear, with no discontinuities. There was essentially no lateral airspeed error in hover; however, the error increased as sideward airspeed increased. For the 10-foot skid height condition, there was a slight degradation in system performance in the area of hover to 15 KTAS left and right. The maximum error was 6 KTAS at 36 KTAS in left sideward flight.

HIGH-SPEED FORWARD FLIGHT

14. System performance in high-speed forward flight is very good, as shown in figure 1, appendix D. The greatest error was 4 KTAS for a forward airspeed range from 30 to 122 KTAS. The longitudinal system improvement achieved with the LORAS 1000 compared with LORAS II (ref 3, app A) is illustrated by figure A.

CROSS-COUPLING CHARACTERISTICS

15. Cross-coupling of longitudinal and lateral airspeed is illustrated by figures 1 and 2, appendix D. The high-speed cross-coupling error previously reported for LORAS II (ref 3, app A) has been corrected in LORAS 1000. The maximum cross-coupling error observed was 3 knots in longitudinal flight and 5 knots in lateral flight.

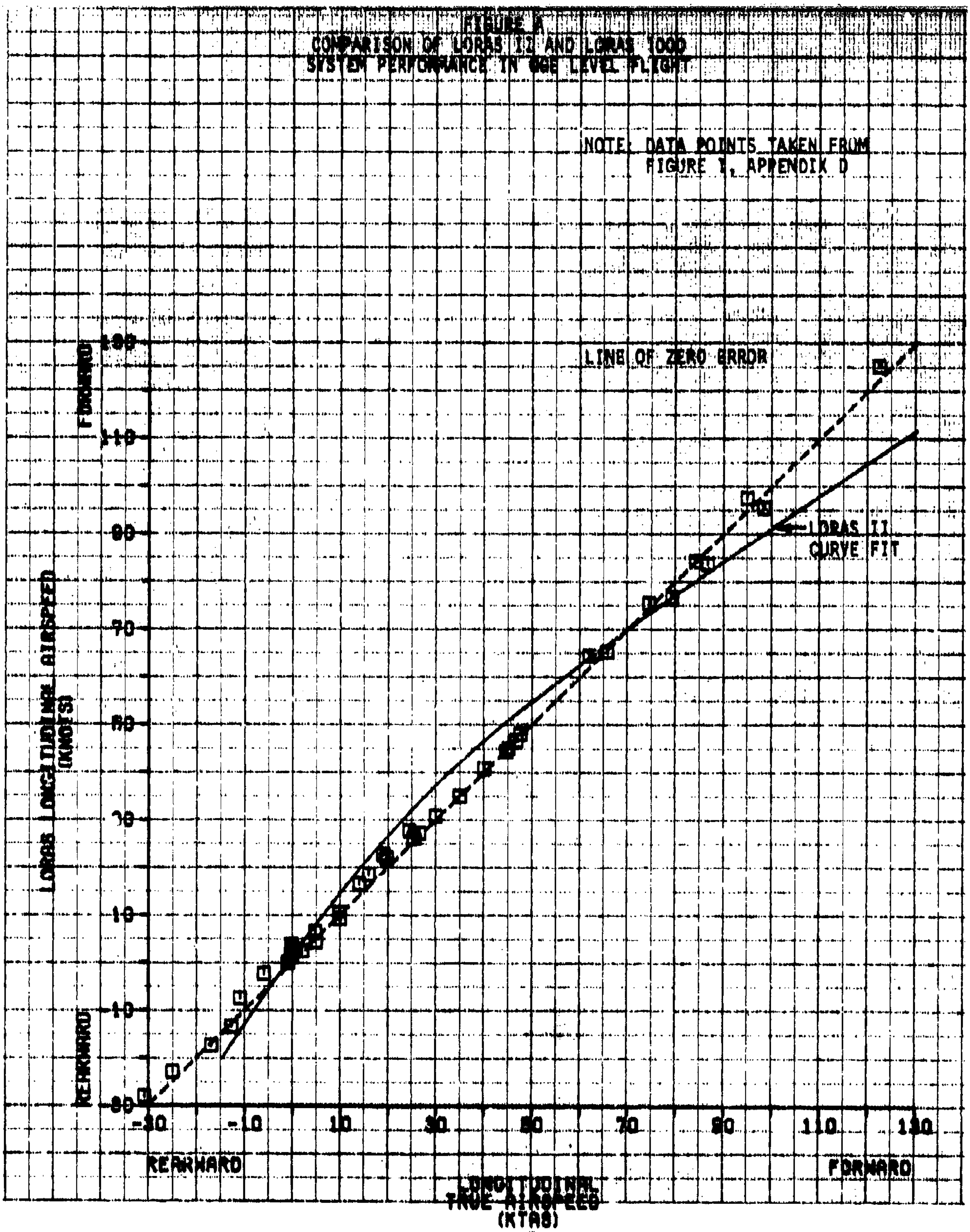
FIGURE A
COMPARISON OF LORAS II AND LORAS 1000
SYSTEM PERFORMANCE IN OGE LEVEL FLIGHT
NOTE: DATA POINTS TAKEN FROM
FIGURE 1, APPENDIX D
LINE OF ZERO ERROR
LORAS II
CURVE FIT
FORWARD
REARWARD
LORAS LONGITUDINAL AIRSPEED
(KNOTS)
110
90
70
-30
-10
10
30
50
70
90
110
130
REARWARD
FORWARD
LONGITUDINAL
TRUE AIRSPEED
(KTAS)

SIDESLIP CHARACTERISTICS

16. Sideslip effects on system longitudinal error are shown in figure 3, appendix D. At flight path velocities up to 33 KTAS, there were random errors in longitudinal airspeed of up to approximately 7 KTAS, with no consistent trend for sideslip effects. For an airspeed of 58 KTAS, the longitudinal airspeed component was not affected by left sideslip. However, right sideslip caused the system error to increase as sideslip became greater. The error was 4 KTAS at 30 degrees right sideslip. At 112 KTAS, the system indicated high for left sideslips and low for right sideslips.

17. Lateral system errors with sideslip, shown in figure 4, appendix D, exhibited no consistent trend for airspeeds of 33 KTAS and below. The random error was generally between ±5 KTAS. For the 58-KTAS case, the characteristics indicated a right error for left sideslip and a left error for right sideslip. The variation was essentially linear and was on the order of 5 KTAS at 30 degrees of sideslip. At 112 KTAS, the system had a maximum error of 1 knot between -5 and +10 degrees of sideslip. At 15 degrees left sideslip, the error increased to 6 KTAS.

EFFECTS OF CLIMBS AND DESCENTS

18. The effects of fuselage angle of attack on airspeed system performance are presented in figure 5, appendix D. Low rates of descent and climbs (±500 feet per minute (ft/min)) at 58 KTAS produced longitudinal airspeed errors less than 3 KTAS. High angle of attack descents at low true airspeed produced significant longitudinal error. For a +16.8-degree angle of attack (1400 ft/min rate of descent) the longitudinal error was 16 KTAS. The lateral airspeed component was less than 5 KTAS for angles of attack between +15 and -17 degrees. The system was more sensitive to angle of attack at an airspeed of 115 KTAS. Longitudinal error change was 10 KTAS for an angle of attack change from +6 to -8 degrees. For the same range, the lateral error change was 5 KTAS. The longitudinal accuracy of the system in high angle of attack descent should be improved.

DENSITY ALTITUDE COMPUTATION ERROR

19. The density altitude display operated only when the system was in the test mode. System output was within 250 feet (the resolution of the indicator) of the value calculated, using instrumentation ambient temperature and pressure altitude for all conditions tested.

20. A continuous display of density altitude information is desirable and should be incorporated in future LORAS.

COCKPIT DISPLAY

20. The cockpit display provided with the LORAS 1000 was a fixed-background movable cross-bar type indicator tailored after doppler ground speed displays (photo 3, app B) The fixed background has a reference circle with a cross-mark at its center and vertical and horizontal graduated axes. The intersection of the bars indicates resultant airspeed and the azimuth angle of relative wind. When the bars cross in the center of the circle, the true airspeed is zero. To zero airspeed along a given axis, the pilot displaces the cyclic control in the direction opposite to the displacement of the bar. To zero sideslip, the pilot applies pedal in the direction the bar is displaced. No numerical value for the angle of sideslip is available.

21. A pointer on the left edge of the display indicates the flight path airspeed within a range of zero to 150 KTAS. Density altitude is presented across the lower edge of the display with a range of zero to +10,000 feet. The display system was acceptable for crewmember use.

SYSTEM RELIABILITY AND MAINTAINABILITY

22. The system operated reliably throughout the test. System installation did not significantly increase aircraft maintenance workloads. However, the system was tested under a limited range of environmental conditions. The effects of rain, ice, and temperature extremes on system reliability and maintainability should be investigated. Within the scope of this test, system reliability was acceptable.

CONCLUSIONS

23. LORAS output in forward and rearward flight was linear throughout the range tested (30 KTAS rearward to 122 KTAS forward) except for small discontinuities at -10 and +10 KTAS (paras 12 and 14).

24. Ground proximity increased the discontinuities in forward and rearward flight (para 12).

25. The system output in lateral flight was repeatable and essentially linear, with no discontinuities (para 13).

26. The high-speed cross-coupling error previously reported for LORAS II has been corrected in LORAS 1000 (para 15).

27. High angle of attack descents at low true airspeed produced significant longitudinal error (para 18).

28. The LORAS 1000 density altitude display was within ±250 feet (the resolution of the indicator) of the value calculated using instrumentation ambient temperature and pressure altitude readings (para 19).

29. The cockpit display presented was acceptable for crewmember use (para 21).

30. Within the scope of this test, system reliability was acceptable (para 22).

RECOMMENDATIONS

31. The longitudinal accuracy of the system in high angle of attack descents should be improved (para 18).

32. A continuous display of density altitude information is desirable and should be incorporated in future LORAS (para 20).

33. The effects of rain, ice, and temperature extremes on system reliability and maintainability should be investigated (para 23).

APPENDIX A. REFERENCES

1. Final Report I, US Army Aviation Systems Test Activity (USAASTA), Project No. 71-30, *Flight Evaluation, Elliott Low Airspeed System*, September 1972.

2. Final Report II, USAASTA, Project No. 71-30, *Flight Evaluation, Aeroflex True Airspeed Vector System, Low-Airspeed System*, March 1973.

3. Final Report III, USAASTA, Project No. 71-30, *Flight Evaluation, Pacer Systems Inc. LORAS II Low Airspeed System*, March 1974.

4. Final Report IV, USAASTA, Project No. 71-30, *Flight Evaluation, J-TEC Airspeed System, Low Airspeed Sensor*, April 1974.

5. Final Report V, USAAEFA, Project No. 71-30, *Flight Evaluation, Rosemount Orthogonal Low Airspeed System, Low Airspeed Sensor*, November 1974.

6. Final Report VI, USAAEFA, Project No. 71-30, *Flight Evaluation, Elliott Dual-Axis Low Airspeed System, LASSIE II, Low Airspeed Sensor*, September 1975.

7. Letter, AVSCOM, AMSAV-EQI, 12 May 1975, subject: AVSCOM Test Request No. 75-17, Flight Evaluation of Two Low Airspeed Sensing Systems.

8. Test Plan, USAAEFA Project No. 75-17, *Flight Evaluation of Two Low Airspeed Sensing Systems*, September 1975.

9. Technical Manual, TM 55-1520-221-10, *Operator's Manual, Army Model AH-1G Helicopter*, 19 June 1971, with Changes 1 through 11.

10. Letter, AVSCOM, AMSAV-EQA, 8 January 1976, subject: Safety-of-Flight Release for AH-1G With Pacer System and Honeywell Low Airspeed Sensor Installed.

11. Report, Pacer Systems Inc., *LORAS II Low Range Airspeed System*, 24 January 1973.

APPENDIX B. SYSTEM DESCRIPTION AND THEORY OF OPERATION

GENERAL

1. The LORAS 1000 consists of a sensor unit, air data converter, omnidirectional airspeed/density altitude indicator, and control panel. The sensor was mounted on a standpipe which provided a stationary platform above the rotor hub, as shown in photo 1. The system components are shown in photo 2. The system part numbers and manufacturer's system specifications are listed below. A detailed description of the LORAS is contained in the contractor's specification (ref 11, app A).

SYSTEM COMPONENTS AND PART NUMBERS

Sensor assembly	PB-7305-R073-1
Air data converter	PB-7305-D045A
Omnidirectional airspeed/density altitude indicator	PB-7305-B066
Control panel	PB-7305-A067-1

MANUFACTURER'S SPECIFICATIONS

Electrical

Power Requirement:

DC 28 VDC ±4V 20 watts
AC 115 VAC ±10%, 400 Hz, single phase: 60 VA

System Outputs: (50 mv/knot)

Longitudinal channel ±150 knots = +7.5 VDC
Lateral channel ±150 knots = +7.5 VDC
Total velocity channel ±150 knots = +7.5 VDC

Mechanical

LORAS 1000 Sensor Assembly:

Rotor diameter	12.30 in.
Mounting base diameter	2.86 in.
Total height	9.54 in.
Weight	2.25 lb

Photo 1. System Installation.

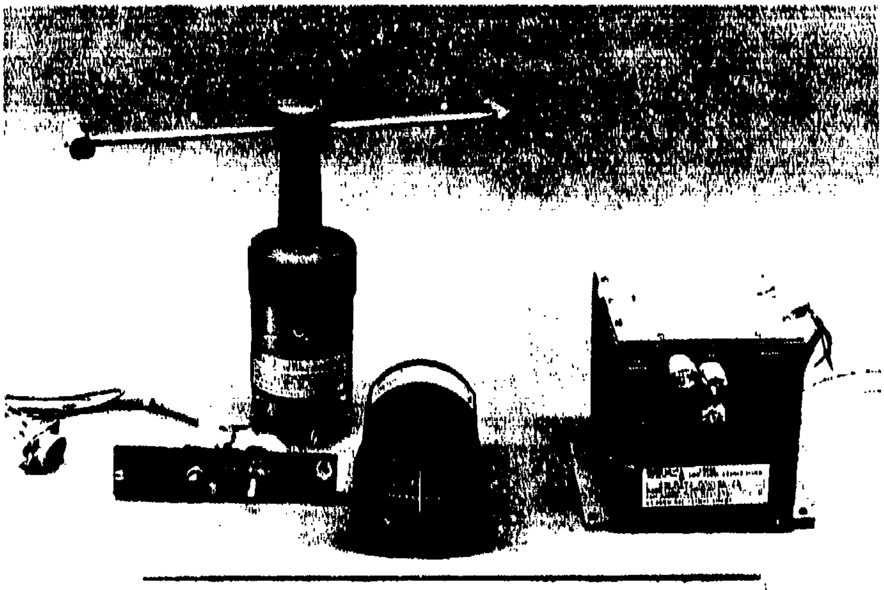

Photo 2. LORAS 1000 Components.

Air Data Converter:

Height	5.25 in.
Width (case)	4.63 in.
Total width (includes mounting brackets)	5.98 in.
Depth	6.12 in.
Weight	2.88 lb

Optional System Accessories:

Omnidirectional airspeed/density altitude indicator	
Case diameter	3.13 in.
Depth (with connector)	6.38 in.
Weight	1.6 lb

Control Panel:

Height	1.31 in.
Width	5.75 in.
Depth	2.5 in.
Weight	0.8 lb

Environmental

Vibration	MIL-E-5400, Curve IV
Temperature	-54 to +55°C

SENSOR UNIT

2. The sensor unit consists of a stainless steel rotor assembly mounted on an aluminum base, as shown in figure 1. The unit weighs 2.25 pounds and the diameter of the rotating assembly is 12.3 inches. Two unheated venturi tubes are orientated on the tips of the rotor. They are driven at 720 rpm by a constant-speed motor mounted on the base of the unit. Cooling for the motor is provided by an integral fan. The static pressure source and outside air temperature probe also are mounted in the base of the sensor. The venturi tubes are connected to either side of a solid-state differential pressure transducer mounted in the hub. The transducer converts the pressure input into an electrical signal which is sent to the air data converter. The rotational angles of the arms are tracked by a separate electrical system which also provides a signal to the air data converter. A simplified mechanical diagram of the sensor unit is shown in figure 2.

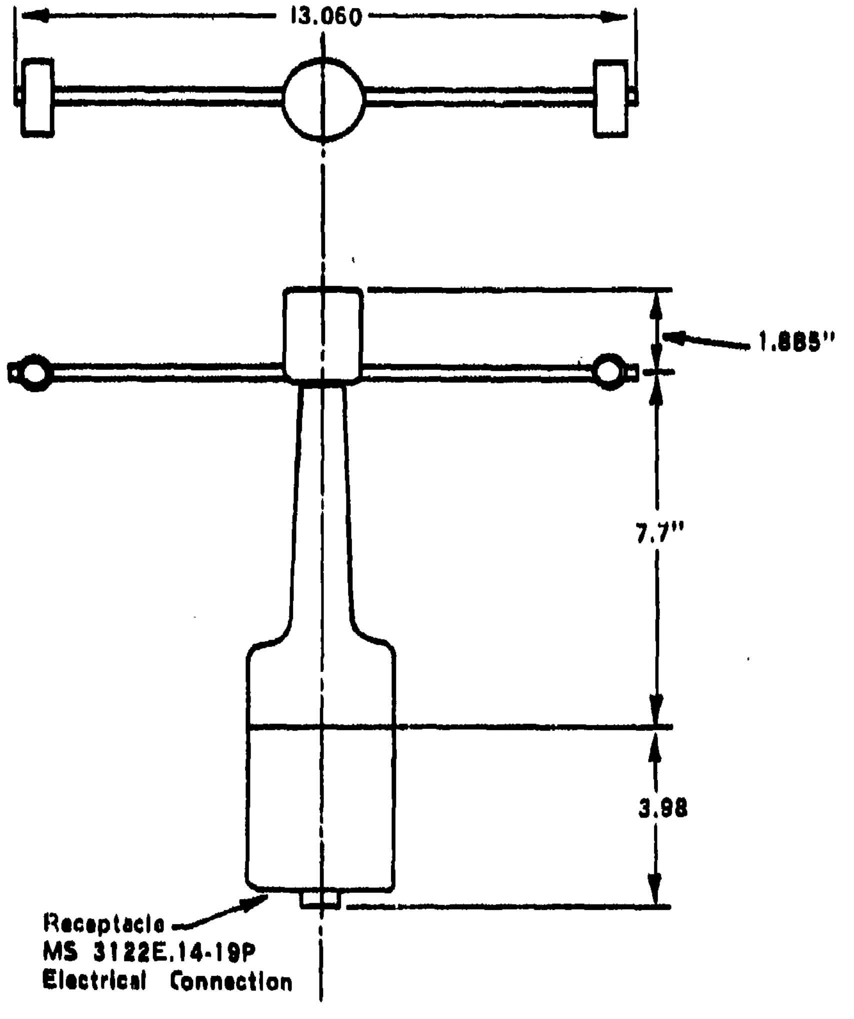

Figure 1. LORAS 1000 Rotor Head Assembly.

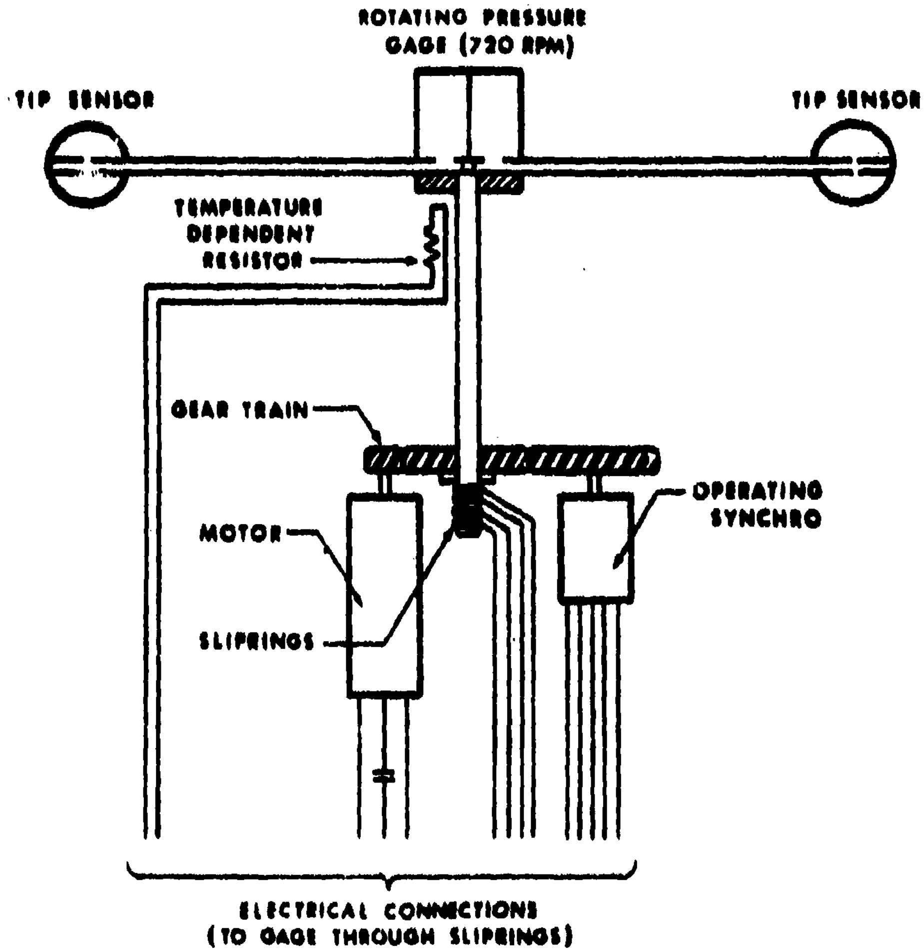

Figure 2. Simplified Mechanical Diagram.

3. The total velocity ($\overline{V}_t$) in each venturi tube consists of a steady component from the constant rotational speed (V_ω = 37.7 ft/sec) and a sinusoidal component at rotational frequency from the translation velocity ($\overline{V}_T$) in the plane of the LORAS 1000 rotating sensor. The arms transmit dynamic pressure readings to the differential pressure transducer. The output of the transducer increases linearly with increases in the magnitude of differential pressure.

4. When the aircraft is hovering in zero wind conditions, the flow through both venturis is equal and the transducer diaphragm does not deflect (fig. 3).

5. When the aircraft begins to translate (or wind is introduced), the total velocity of the advancing venturi increases, and the total velocity of the retreating venturi decreases (fig. 4). Therefore, pressure is reduced in the advancing venturi and increased in the retreating venturi because of the decrease in total velocity. The transducer diaphragm deflects toward the low pressure side and transmits an electrical signal to the air data converter. A separate electric subsystem tracks the rotation angle of the arm system and transmits this information to the air data converter.

AIR DATA CONVERTER

6. The air data converter receives signals from the omnidirectional airspeed sensor and outputs flight path information as either true or calibrated airspeed. It is a solid-state unit which weighs 2.88 pounds and has a volume of 0.12 cubic feet. It can be hard- or soft-mounted to the aircraft, and is connected to the sensor via a single cable. The sensor output is first processed within a density compensation circuit which provides correction for air density so that either true or indicated airspeed can be displayed. Additional inputs to the density compensation circuit are via self-contained, solid-state pressure and temperature sensors. The density compensation circuit can be used to drive a pilot display signal which is proportional to density altitude.

7. Resultant airspeed is derived directly from the density compensated signal. Signals representative of the longitudinal and lateral velocities are obtained from the compensated velocity signal and the angular position of the rotating arms. The angular position is obtained from a synchro/resolver combination. These signals are demodulated and filtered to remove the modulation frequency due to rotation.

8. An azimuth alignment knob is located on the front case of the air data converter. This knob allows maintenance personnel to electrically align the x axis of the sensor with the x axis of the aircraft via a bore-sighting alignment-type adjustment. A built-in test (BIT) feature provides for a GO/NO-GO preflight check and enables maintenance personnel to check the calibration of the system in the field with DC voltmeters.

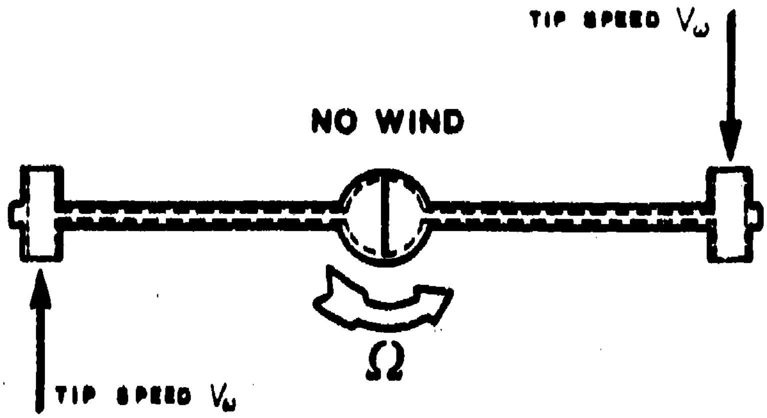

Figure 3. LORAS Transducer in Hover.

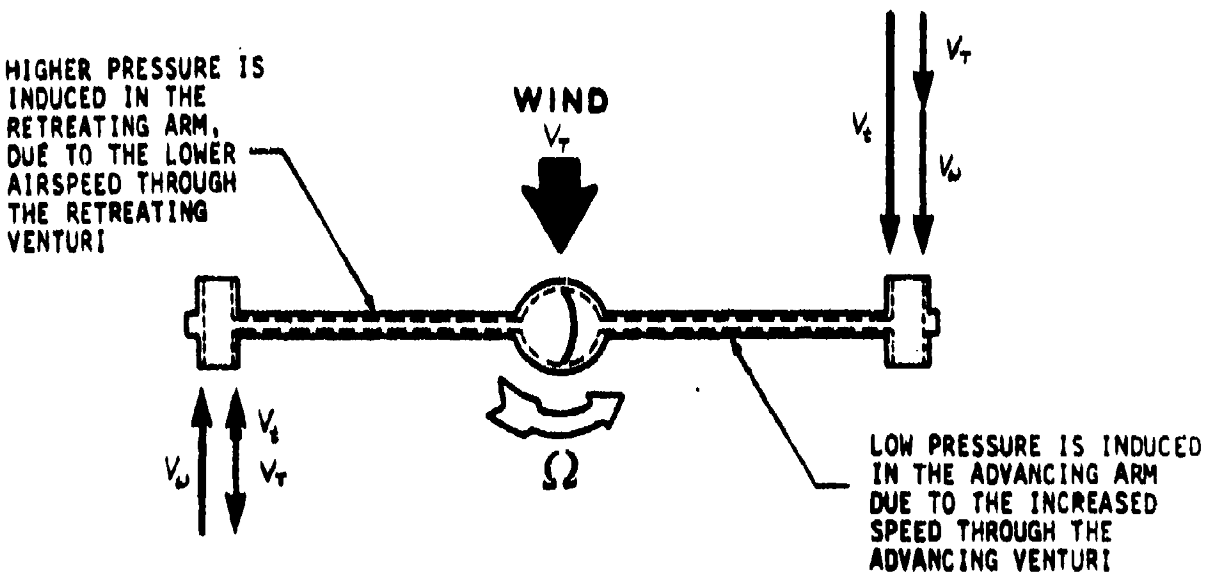

Figure 4. LORAS Transducer in Translational Flight.

DISPLAY

9. LORAS output is displayed in the cockpit on a fixed-background movable crossbar-type indicator weighing 1.6 pounds which is tailored after doppler ground speed displays (photo 3). The unit weighs 1.6 pounds and has vertical and horizontal bars which indicate aircraft airspeed in knots. The fixed background bar has a reference circle with a crossmark at its center. Although the prototype indicator was symmetrical, the reference circle can be offset from the center of the display so that more of the indicator is allocated to forward flight. The horseshoe-shaped dashed line on the indicator face represents the particular aircraft's safety-of-flight envelope limits. Angle reference cues are provided by dash marks extending outward from the center of the display. The ends of the marks form circles of constant flight path airspeed. A pointer on the left edge of the display indicates the flight path airspeed from zero to 150 knots in 10-knot increments. Density altitudes from zero to +10,000 feet are shown in 1000-foot increments.

10. The displacement of the movable vertical and horizontal bars from the center of the background reference circle indicates lateral and longitudinal velocities, respectively. When forward airspeed is generated, the horizontal bar moves up the scale, and when right (left) sideward airspeed is generated, the vertical bar moves to the right (left). The intersection of the bars also indicates the azimuth angle of the relative wind.

11. Other indicator systems such as moving tapes, digital display, light systems, single-axis meters, and flight direction bars also can be adapted to display the output of the LORAS.

CONTROL PANEL

12. The control panel provides control and test functions for the LORAS 1000. The panel includes an ON/OFF switch and a spring-loaded test switch, DENS/ALT, that connects the system either to the main power source or to the BIT circuit. When the test switch is moved to the TEST position, two separate operations take place. The pointer for the density altitude portion of the cockpit display moves to the current density altitude. At the same time, the airspeed crossbars displace to a preset value. When the TEST switch is released, the density altitude pointer returns to zero and the crossbars return to the reference circle.

SENSOR LOCATION

13. Pacer Systems Inc. recommends locating the LORAS sensor above the main rotor hub. This location minimizes the obstructions to the sensor's sampling of free stream flow. A vertical component of rotor flow is generally expected in the hub area but the LORAS sensor is designed to ignore this high angle-type flow.

Photo 3. Cockpit Indicator.

14. A standpipe-type installation was required to locate the LORAS sensor on top of the main rotor hub. This standpipe was nonrotating and was attached to the bottom of the main transmission and extended through the hollow main rotor shaft. A bearing was used to center the standpipe at the top of the main rotor mast. A typical standpipe installation is shown in figure 5.

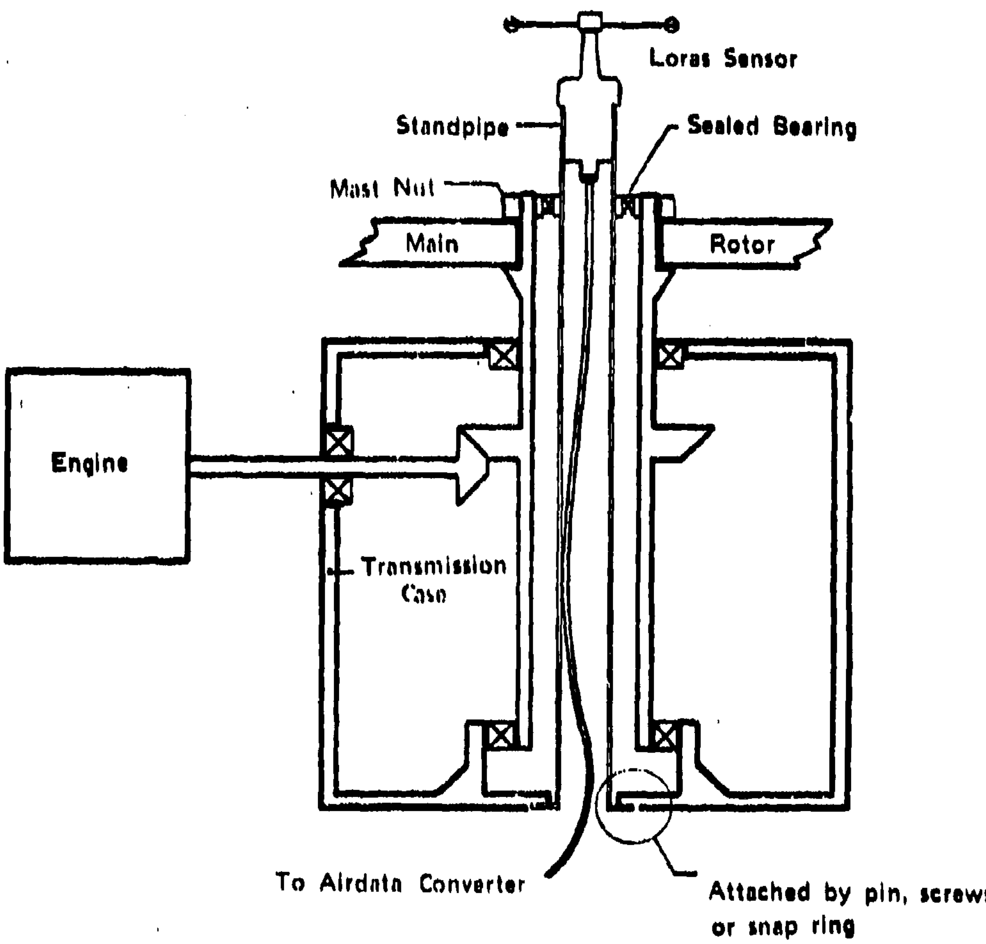

Figure 5. Typical Standpipe Installation.

APPENDIX C. TEST INSTRUMENTATION

1. The following parameters were recorded on board the test helicopter on magnetic tape and were also capable of telemetry transmission.

Parameter	Normal Calibration Range
Time of day (B)[1]	Hr, min, sec, millisec
Engineer event (B)	Off/zero, on/128 counts
Run number counter (B)	Zero to 127 counts
Test boom altitude	1000 to 8000 ft
Test boom airspeed	20 to 140 KCAS
Outside air temperature (total)	-10 to 50°C
Angle of attack	-45 to +45 deg
Angle of sideslip	-45 to +45 deg
Rotor speed	250 to 350 rpm
Pitch attitude	-30 to +30 deg
Roll attitude	-60 to +60 deg
LORAS 1000 longitudinal airspeed	-50 to +150 KTAS
LORAS 1000 lateral airspeed	-50 to +50 KTAS

2. The following parameters were hand-recorded on the ground (when required).

Parameter	Normal Calibration Range
Wind speed	Zero to 35 KTAS
Wind direction	Zero to 360 deg
Pace vehicle speed	Zero to 50 KTAS
Pace vehicle heading	Zero to 360 deg
Aircraft heading	Zero to 360 deg

3. The following parameters were displayed on the engineer panel.

Parameter	Normal Calibration Range
Time of day	Hr, min, sec
Run counter	Zero to 127 counts
Outside air temperature	-10 to 60°C
Test boom airspeed	15 to 140 KCAS
Test boom altitude	1000 to 8000 feet

[1] B: Bilevel channel (all others zero to 5-volt DC analog).

4. The following parameters were displayed on the pilot panel.

Parameter	Normal Calibration Range
Test boom altitude	1000 to 8000 feet
Test boom airspeed	15 to 140 KCAS
Angle of sideslip	±45 deg
Rotor speed (sensitive)	220 to 350 rpm
Rotor/output shaft speed (ship's)	Not calibrated
Engine torque pressure	Not calibrated
Compressor speed	Not calibrated
Exhaust gas temperature	Not calibrated
Aircraft heading (magnetic)	Not calibrated
LORAS 1000 longitudinal airspeed	-30 to 60 KCAS
LORAS 1000 lateral airspeed	-35 to 35 KCAS

APPENDIX D. TEST DATA

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FIGURE 1

SYSTEM PERFORMANCE IN FORWARD AND REARWARD FLIGHT

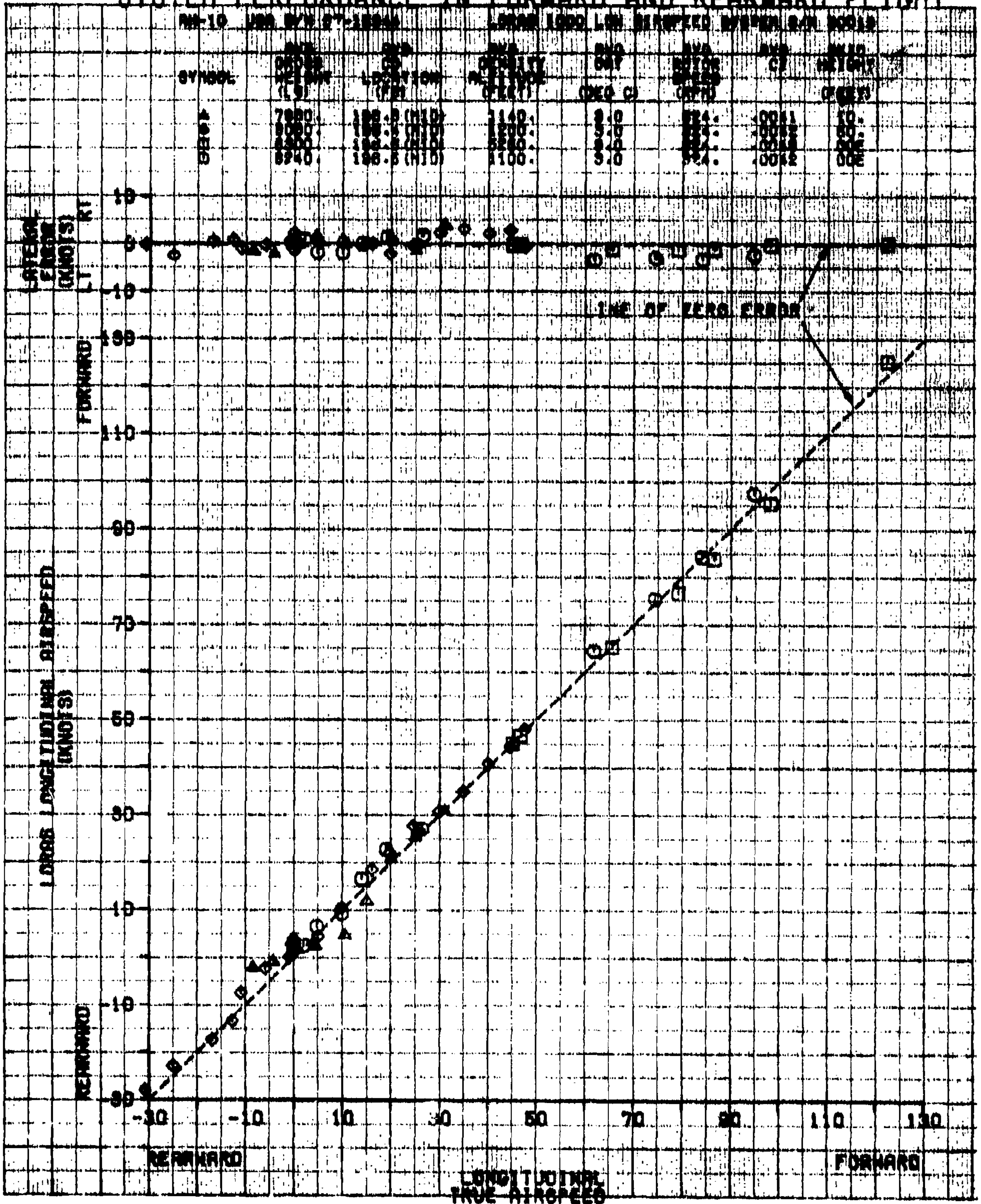


FIGURE 2

SYSTEM PERFORMANCE IN SIDEWARD FLIGHT

AH-1G USA S/N 67-15[illegible] LORAS [illegible] LOW AIRSPEED SYSTEM S/N [illegible]

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG CT	SKID HEIGHT (FEET)
◆	7730.	192.1 (MID)	1880.	9.0	321.	.0040	50.
▲	7600.	192.8 (MID)	1880.	9.5	321.	.0038	10.

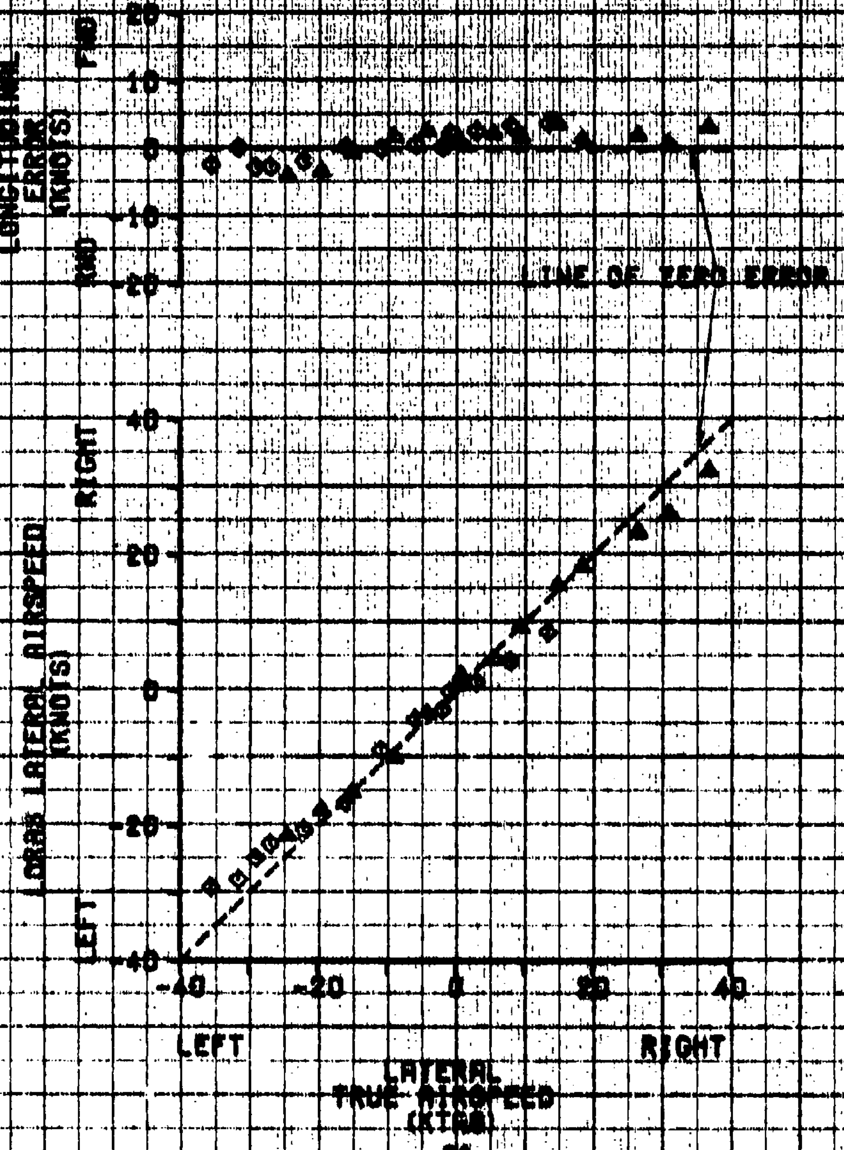


FIGURE 2

SIDESLIP EFFECTS ON SYSTEM LONGITUDINAL ERROR

AH-1G USA S/N 67-15644 LORAS 1000 LOW AIRSPEED SYSTEM S/N 20018

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG CT	SKID HEIGHT (FEET)
△	8180.	196.5 (MID)	5400.	9.0	324.	.0048	OGE
◇	8050.	196.4 (MID)	5410.	9.0	324.	.0047	OGE
□	7920.	196.3 (MID)	1680.	7.0	324.	.0041	50.
○	8050.	196.4 (MID)	1720.	7.5	324.	.0042	50.
X	8190.	196.5 (MID)	1600.	[illegible]	324.	.0045	50.

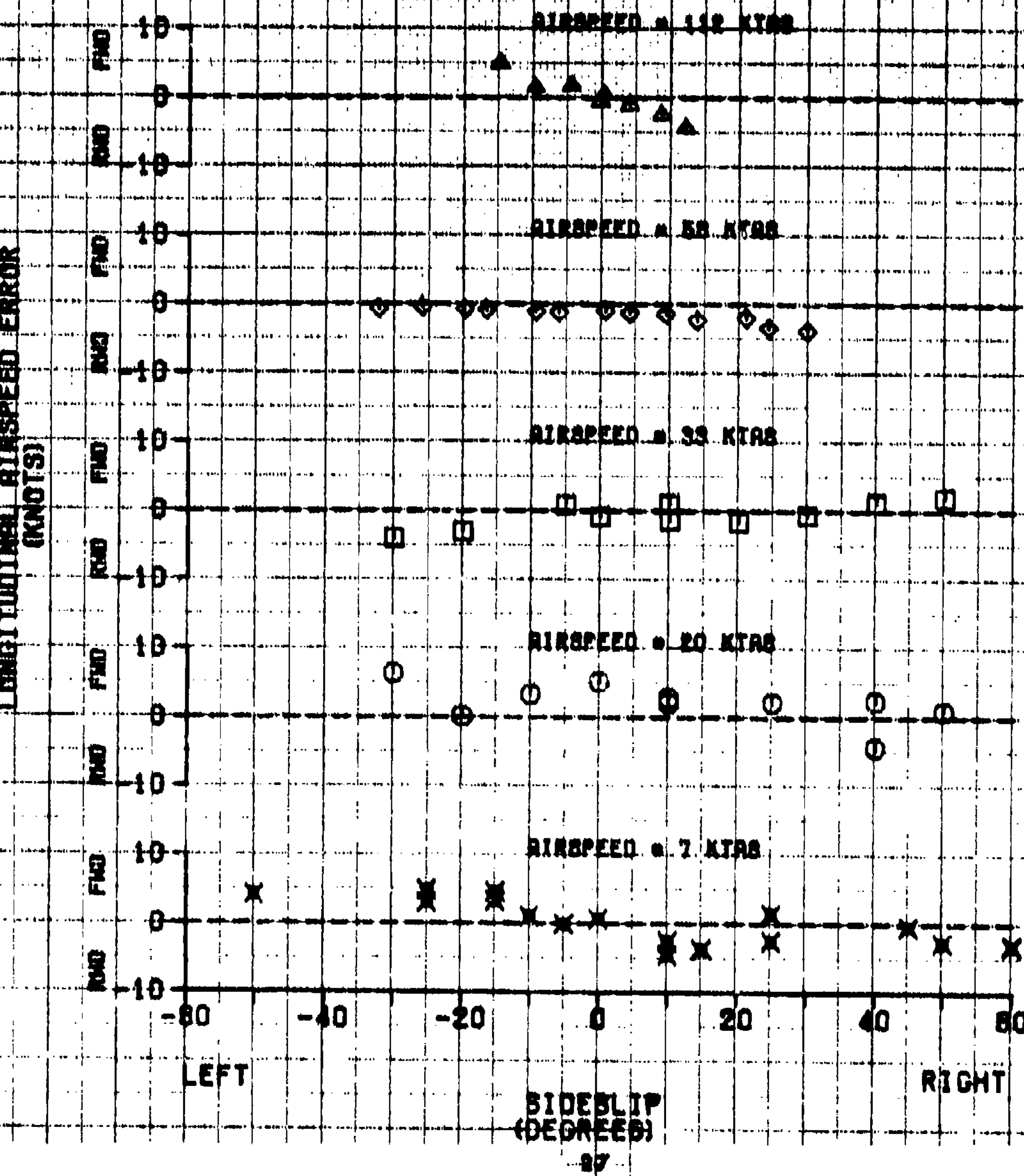


FIGURE 8

SIDESLIP EFFECTS ON SYSTEM LATERAL ERROR

AH-1G USA S/N 67-15[illegible] [illegible] LAAS AIRSPEED SYSTEM S/N [illegible]

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG CT	SKID HEIGHT (FEET)
▲	8190.	19[illegible] (MID)	3400.	9.0	324.	.0049	OGE
◇	8060.	19[illegible] (MID)	[illegible]	9.0	324.	.0047	OGE
□	7920.	19[illegible] (MID)	[illegible]	7.0	324.	.0041	50.
○	8050.	19[illegible] (MID)	1720.	7.5	324.	.0042	50.
X	8190.	19[illegible] (MID)	1660.	8.0	324.	.0046	50.

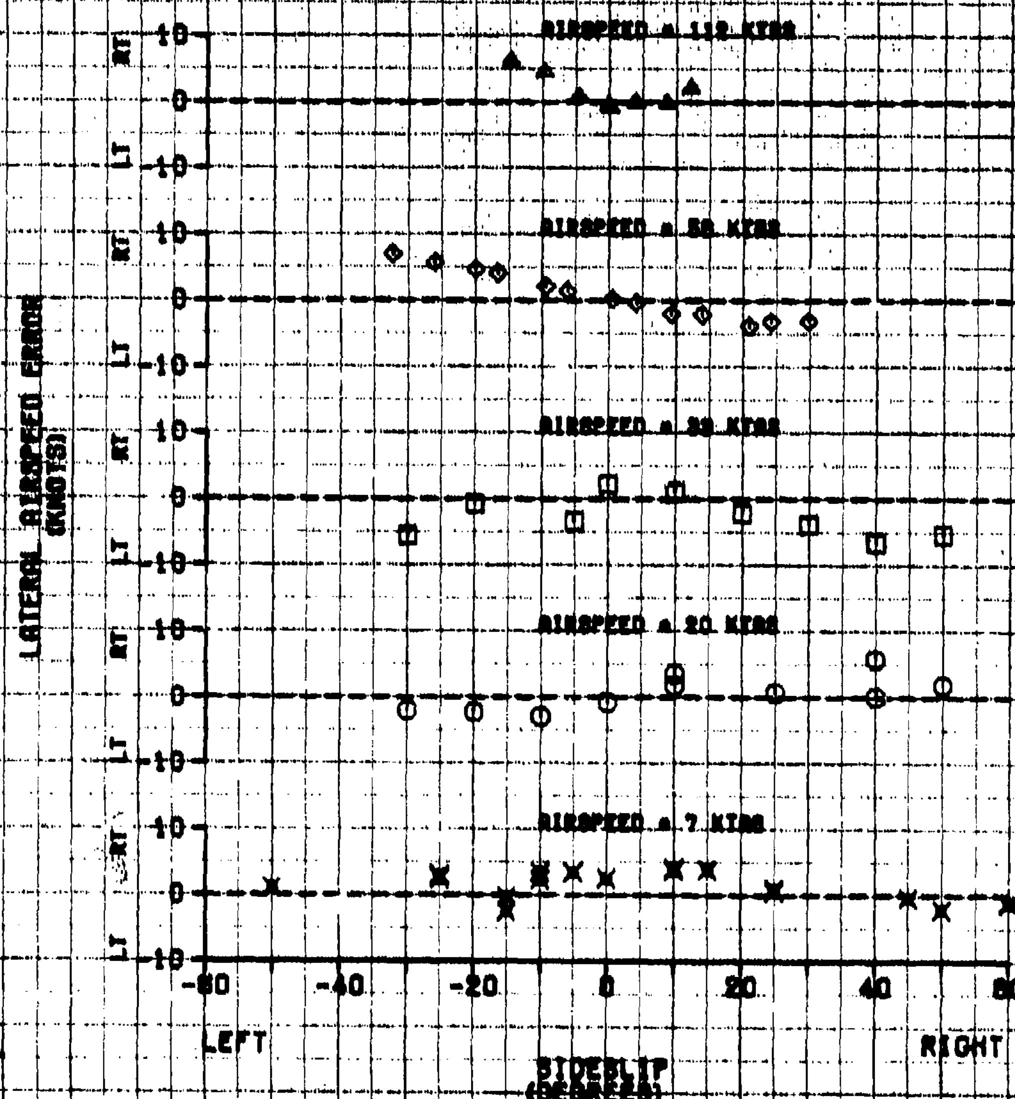


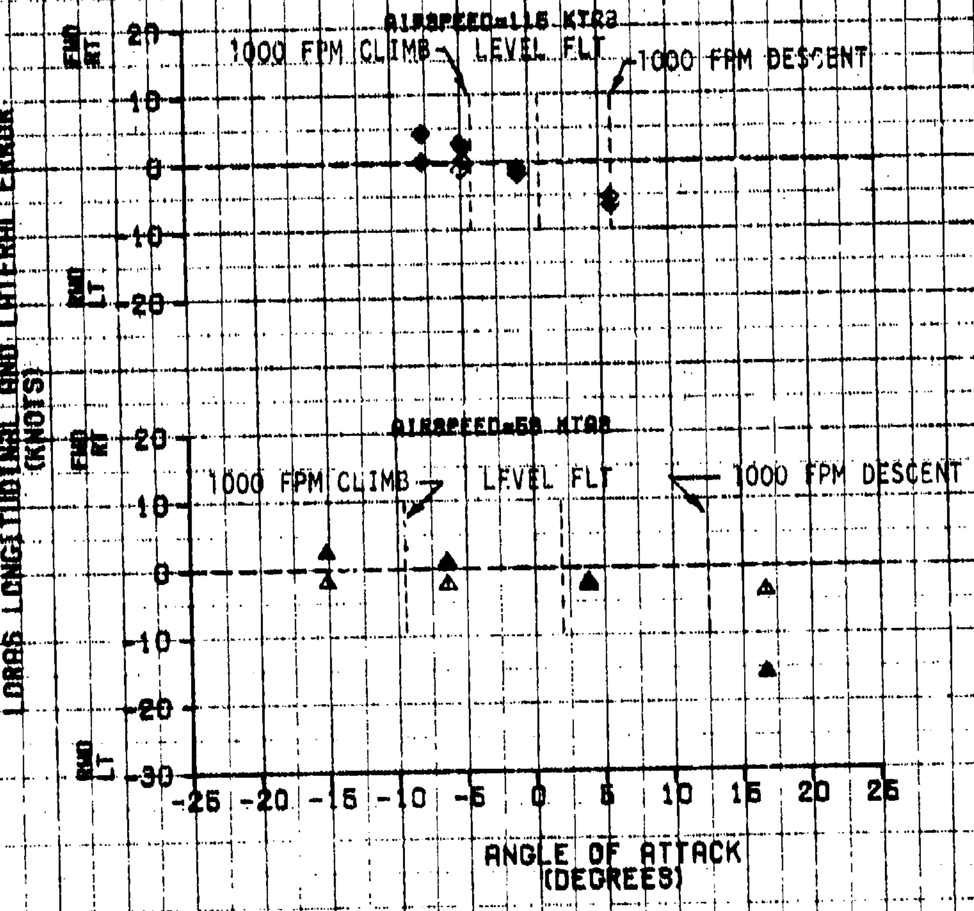
FIGURE 15

EFFECTS OF CLIMBS AND DESCENTS ON SYSTEM ERROR

AH-1G USA S/N 67-15944 LORAS 1000 LOW AIRSPEED SYSTEM S/N 00019

SYMBOL	AVG GROSS WEIGHT (LB)	AVG CG LOCATION (FS)	AVG DENSITY ALTITUDE (FEET)	AVG OAT (DEG C)	AVG ROTOR SPEED (RPM)	AVG CT	SKID HEIGHT (FEET)
▲	7880.	196.2 (MID)	6960.	6.0	324.	.0048	OGE
◆	7840.	196.3 (MID)	6940.	6.0	324.	.0049	OGE

NOTES: 1) SHADED SYMBOLS DENOTE LONGITUDINAL ERROR
2) OPEN SYMBOLS DENOTE LATERAL ERROR



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